	Scenario 1		in on and off		inford Intercl	53	
			Wick I	Drain Spaci	ng (feet)		
		Shumway Hollow Road			Lucasville-Minford Road		Estimated
		Area 1	Area 2	Area 3	CR 28 Ramps	Mainline	Costs
		6	6	5	7	7	
	Option 1	1949 Date: 1969	approximate		terchange cou into the third	5.410	\$4,104,577
		6	6	5	6	7	
	Option 2	Paving cou season	ild begin at th	ne beginning	of the third c	onstruction	\$4,147,733
			and D will be	paved and o	ucasville-Mi pened to traf		anges,
			Wick	Drain Spaci	ng (feet)		
	Scenario 2	Shumway Hollow Road			Lucasville-Minford Road		Estimated Costs
		Area 1	Area 2	Area 3	CR 28 Ramps	Mainline	Custs
		5	5	5	7	7.	
	Option 1	Paving at the Lucasville-Minford Interchange could not begin until approximately 23 weeks into the third construction season.					\$4,275,931
		5	5	5	6	6	
	Option 2	Paving cou season	ıld begin at t	he beginning	of the third o	construction	\$4,383,857
		Shumway Hollow Interchange Ramps A & D will be paved an traffic. Additional time allowed for consolidation of embankn Shumway Hollow Road (TR 234). At Lucasville-Minford Inter Ramps A & D will be opened to traffic.					nent south of
	Scenario 3		Wick Drain Spacing (feet)				Estimated
		Shumway Hollow Road			Lucasville-Minford Road		
		Area 1	Area 2	Area 3	CR 28 Ramps	Mainline	Costs
		6	6/5	5	7	7	
	Option 1		l approximat		terchange co s into the thir		\$4,199,857
		6	6/5	5	6	7	
						1 /	1



<u>Scenario 1</u> – Shumway Hollow and Lucasville-Minford Interchanges will utilize Ramp D as both an on and off ramp.

Option 1: Wick drains are spaced differently between Areas 1 & 2 and Area 3 {see attached, from *Addendum to Report: Shumway Hollow Road (TR 234) Interchange* (DLZ, 2008)}. Total Cost = \$4,104,577

- Wick drains at TR 234 Ramp D and along the Mainline Embankment from Sta. 384+00 to Sta. 415+00 (Area 3) spaced at 5 feet.
- Wick drains along Mainline Embankment from Sta. 352+00 to 384+00 and along TR 234 ramps A, B, and C (Areas 1 & 2) spaced at 6 feet.
- All wick drains at the Lucasville-Minford Interchange spaced at 7 feet.
- Complete embankments in 2 construction seasons.
- Reach 90% consolidation of TR234 Ramp D and mainline embankment from Sta. 384+00 to Sta. 415+00 in second construction season.
- Reach 90% consolidation of TR234 Ramps A, B and C, Mainline Embankment Sta. 352+00 to Sta. 384+00, and entire Lucasville-Minford Interchange in third construction season.

Constructability Benefits/Issues with Option 1

- Paving along Ramp D and Mainline Embankment from Sta. 384+00 to Sta. 415+00 could start at beginning of third construction season.
- Paving at the Shumway Hollow Interchange could begin approximately 11 weeks into the third construction season.
- Paving at the Lucasville-Minford Interchange could begin approximately 23 weeks into the third construction season.

Option 2: Wick drains are spaced differently between Areas 1 & 2 and Area 3 at the Shumway Hollow Interchange; and between the ramps and the mainline embankment at the Lucasville-Minford Road Interchange. Total Cost = \$4,147,733

- Wick drains along Ramps A, B, C and D at the Lucasville-Minford Interchange spaced at 6 feet.
- Remaining areas at the Lucasville-Minford Interchange including the Mainline Embankment from Sta. 520+00 to Sta. 537+00 to have wick drains spaced at 7 feet.
- Wick drains along Mainline Embankment from Sta 352+00 to 384+00 and along Ramp D at Shumway Hollow Interchange spaced at 5 feet.
- Remaining areas at Shumway Hollow Interchange, including Ramps B, C and D and Mainline Embankment Sta. 352+00 to Sta. 384+00, to have wick drains spaced at 6 feet.
- Complete embankments in 2 construction seasons.
- Reach 90% consolidation of TR 234 Ramp D, Mainline Embankment from Sta. 384+00 to Sta. 415+00, and Lucasville-Minford Ramps A, B, C and D in the second construction season.

• Reach 90% consolidation of Mainline Embankment Sta. 352+00 to Sta. 384+00, Mainline Embankment Sta. 520+00 to Sta. 537+00, and TR234 Ramps A, B, and C in the third construction season.

Constructability Benefits/Issues with Option 2

• Paving to begin from either intersection at beginning of third construction season.

COMPUTATIONS

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SCENARIO 1

OPTION 1

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		Job No.	79784		PID No.	19415
HD	R Computation]	HDR
Project	SCI-823 Portsmouth Bypass		Computed	JSA	Date	4/17/2008
Subject	CR 28 Interchange		Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case		Sheet	1	Of	1
Sta	ge 1 - 50% Consolidation				· · ·	

Oldge 1 - 0070 Ochsonaulon					
Triangular Pattern					
t (days)	Spacing (ft)	Cost (\$)			
30	3.28	1,378,650			
60	4.71	670,829			
90	5.87	433,683			
120	6.79	325,507			
150	7,49	267,358			
180	8.05	232,164			
210	8.51	208,049			
240	8.95	188,074			
270	9.46	168,555			
300	10.14	147,056			





Total Time					
Triangular Pattern					
t (days)	Spacing (ft)				
92	3.00				
151	4.00				
230	5.00				
332	6.00				
461	7.00				

Consolidation Time vs. Minimum Drain Spacing





HDR Computa	tion
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Job No.

79784

PID No.

19415

HR

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008	
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008	
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2	

References:

- 1. Federal Highway Administration, "Prefabricated Vertical Drains A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
- 2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
- 3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
- 4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Lucasville-Minford Road (CR 28) (DLZ, 2008)

Assumptions:

- 1. Terzaghi's one-dimensional consolidation theory applies.
- 2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
- 3. Effect of disturbance related to soil displacement during installation is negligible.
- 4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	560,368 sf	Total area at CR 28 Interchange to be drained (DLZ, 2008)
C =	\$0.50 cost/lf	Material + Installation Cost
	Single	Vertical Drainage (Single or Double)
	Triangular	Wick Drain Pattern
t =	128 day	available time to achieve desired degree of consolidation U _h
H =	43.5 ft	height of compressible layer
a =	0.33333 ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833 ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c _v =	0.081 ft ² /day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
$c_h =$	0.0972 ft ² /day	coefficient consolidation for horizontal drainage
j	Note:	
	-General Case: c _h =	1.2 to 1.5*c _v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: ch = up to 10*cv

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$
 (See FHWA eq.

where,

- U = overall average degree of consolidation
- U_h = average degree of consolidation due to horizontal (or radial) drainage

1)

 U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

 $\begin{array}{ccccccc} U_{h}=& 0~\%\\ U_{V}=& 50~\%\\ U=U_{v}=& 50~\%\\ T_{v}=& 0.19625 \end{array} t= 4585 \ \ \mbox{days} & \ \ \mbox{Need to Consider Other Options.} \end{array}$

Calculate U_v that will occur in design period of t t = 128 day

$$T = \frac{tc_v}{H^2}$$
$$T = 0.01$$

$$U_v = 0.01$$

 $U_v = 0.08$

Calculate required Uh

$$\overline{U} = 1 - (1 - \overline{U}_{h})(1 - \overline{U}_{v})$$
 (See FHWA eq. 1)
U_h = 0.45

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

Job No.

79784

PID No.

19415

$$t = \frac{D^2}{8c_h} F(n) \ln\left[\frac{1}{1 - \overline{U}_h}\right]$$

(See FHWA eq. 8)

where,

 $\begin{array}{rll} t = & 128 \ \text{day} \\ \overrightarrow{U}_{h} = & 0.45 \\ c_{h} = & 0.0972 \ \text{ft}^{2}/\text{day} \\ F(n) = & 2.806234 \end{array}$

available time to achieve desired degree of consolidation U_h average degree of consolidation due to horizontal drainage coefficient of consolidation for horizontal drainage drain spacing factor

where,

 $F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$ (simplified) (See FHWA eq. 3)

 $d_w = 2(a+b)/\pi$ $d_w = 0.23 \text{ ft}$ diameter of an equivalent circular drain (See FHWA eq. 9)

D = 7.902355 ft

required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.





79784 PID No. 19415 Job No. **HDR Computation** SCI-823 Portsmouth Bypass JSA 4/17/2008 Project Computed Date Shumway Hollow Road (TR 234) Interchange: Area #3 (Ramp D Area) DMV 5/1/2008 Subject Date Checked Task Wick Drain Analyses - Idealized Case Sheet 1 Of 1 Stage 1 Triangular Pattern Stage 1 Consolidation Time vs. Cost t (days) Spacing (ft) Cost (\$) 2.15 3,289,069 30 2.65 60 2,158,592 3,500,000 90 3.13 1,545,784 3,000,000 120 3.59 1,177,086 4.03 150 937,347 2,500,000 180 4.44 772,303 2,000,000 210 4.83 653,930 240 5.19 565,905 1,500,000 270 5.53 498,775

	Stage 2	
LL	riangular Patte	rn
t (days)	Spacing (ft)	Cost (\$)
30	2.34	
60	3.01	
90	3.64	
120	4.23	
150	4.77	
180	5.27	
210	5.72	
240	6.14	
270	6.51	
300	6.85	
330	7.15	

5.85

6.15

6.42

6.68

6.92

446,555

404,597

370,900

343,263

320,106

300

330

360

390

420

Total Time				
Triangu	ılar Pattern			
t (days)	Spacing (ft)			
142	3.00			
256	4.00			
386	5.00			
545	6.00			
744	7.00			







Job No. 79784

19415

HDR Computation

HR

Project	SCI-823 Portsmouth Bypass	Computed JSA		Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

- 1. Federal Highway Administration, "Prefabricated Vertical Drains A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
- 2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
- 3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
- 4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

- 1. Terzaghi's one-dimensional consolidation theory applies.
- 2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
- 3. Effect of disturbance related to soil displacement during installation is negligible.
- 4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	842,862	sf	Total Area #3 (Ramp D Area) to be drained (DLZ, 2008)
C =	\$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	225	day	available time to achieve desired degree of consolidation U _h
H =	29	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c _v =	0.081	ft²/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c _h =	0.0972	ft²/day	coefficient consolidation for horizontal drainage
1	Note:		
	Gonoral C		1.2 to 1.5 to

-General Case: c_h = 1.2 to 1.5*c_v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: $c_h = up$ to $10^* c_v$

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$
 (See FHWA eq. 1)

where,

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

 U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U _h =	0 %				
Uv =	90 %	t =	8805	days	Need to Consider Other Options.
$U = U_v =$	90 %				
T _v =	0.848				
ate U., that w	ill occur in design period of t.				

Calculate U_v that will occur in design period of t. t = 225 day

$$T = \frac{tc_v}{H^2}$$
$$T_v = 0.02$$
$$U_v = 0.17$$

Calculate required U_h

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$
$$U_h = 0.88$$

(See FHWA eq. 1)

\mathbf{r}	Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
l	Subject	Shumway Hollow Road (TR 234) Interchange	Checked	DMV	Date	5/1/2008
	Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

Job No.

$$t = \frac{D^2}{8c_h} F(n) \ln \left[\frac{1}{1 - \overline{U}_h}\right]$$

(See FHWA eq. 8)

where,

 $t \approx 225 \text{ day}$ $\overline{U}_{h} = 0.88$ $c_{h} = 0.0972 \text{ ft}^{2}/\text{day}$ F(n) = 2.473098 available time to achieve desired degree of consolidation U_h average degree of consolidation due to horizontal drainage coefficient of consolidation for horizontal drainage drain spacing factor

where,

$$F(n) = \ln \left(\frac{D}{d_w} \right) - 0.75$$
 (simplified) (See FHWA eq. 3)

diameter of an equivalent circular drain (See FHWA eq. 9)

 $d_w = 2(a+b)/\pi$ $d_w = 0.23 \text{ ft}$

D = 5.663406 ft

required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.

79784

PID No.

19415



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: 5.01 ft

Length Outer Edge of Equilateral Triangle (or square) =	1395.17 ft
Number Drain Spaces Along Outer Edge =	278.37 ea
Total number wick drains =	39165 ea
Total linear feet wick drain =	1214115 lf
Estimated total cost =	\$607,057.50

	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/17/2008
Subject	Shumway Hollow Road (TR 234) Interchange: Areas #1 & #2	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	11	Of	1

Job No.

Stage 1								
Т	Triangular Pattern							
t (days)	Spacing (ft)	Cost (\$)						
30	3,152,282							
60	2.65	2,068,878						
90	3.13	1,481,568						
120	3.59	1,128,214						
150	4.03	898,442						
180	4.44	740,265						
210	4.83	626,805						
240	5.19	542,454						
270	5.53	478,113						
300	5.85	428,064						
330	6.15	387,841						
360	6.42	355,555						
390	6.68	329,065						
420	6.92	306,869						

Stage 1 Consolidation Time vs. Cost
3,500,000 3,000,000 2,500,000 2,000,000 1,500,000 1,000,000 500,000 0 30 · 60 90 120 150 180 210 240 270 300 330 360 390 420 Time (days)
Time (days)

79784

Stage 2							
Triangular Pattern							
t (days) Spacing (ft) Cost (\$							
30	2.34						
60	3.01						
90	3.64						
120	4.23						
150	4.77						
180	5.27						
210	5.72						
240	6.14						
270	6.51						
300	6.85						
330	7.15						

Total Time							
lar Pattern							
Spacing (ft)							
3.00							
4.00							
5.00							
6.00							
7.00							





19415

HR

PID No.

Job No.

HDR Computation

HR

19415

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

- 1. Federal Highway Administration, "Prefabricated Vertical Drains A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
- 2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
- 3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
- 4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

- 1. Terzaghi's one-dimensional consolidation theory applies.
- 2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
- 3. Effect of disturbance related to soil displacement during installation is negligible.
- 4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	807,730 sf	Total Areas #1 & #2 to be drained (DLZ, 2008)
C =	\$0.50 co	st/lf Material + Installation Cost
	Single	Vertical Drainage (Single or Double)
	Triangular	Wick Drain Pattern
t =	315 da	y available time to achieve desired degree of consolidation U _h
H =	29 ft	height of compressible layer
a =	0.33333 ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833 ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c _v =	0.081 ft ² /	/day coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c _h =	0.0972 ft ² /	/day coefficient consolidation for horizontal drainage
1	Note:	
	General Case	$c_{\rm c} = 1.2 \text{ to } 1.5^{*} \text{c}$

-General Case: c_h = 1.2 to 1.5*c_v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: $c_h = up$ to $10^* c_v$

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_\nu) \qquad (\text{See FHWA eq. 1})$$

where,

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

 U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U _h =	0 %					
Uv =	90 %		t =	8805	days	Need to Consider Other Options.
$U = U_v =$	90 %					
T _v =	0.848					
late U., that w	ill occur in design i	period of t.				

Calculate U_v that will occur in design period of t. t = 315 day

$$T = \frac{tc_v}{H^2}$$
$$T_v = 0.03$$
$$U_v = 0.20$$

Calculate required U_h

$$\overline{U} = 1 - (1 - \overline{U}_{h})(1 - \overline{U}_{v})$$
 (See FHWA eq. 1)

$$U_{h} = 0.88$$

	Job No.	79784	PID No.	19415
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Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

$$t = \frac{D^2}{8c_h} F(n) \ln \left[\frac{1}{1 - \overline{U}_h} \right]$$

(See FHWA eq. 8)

where,

 $\begin{array}{rll} t = & 315 \ \text{day} \\ \overline{U}_{h} = & 0.88 \\ c_{h} = & 0.0972 \ \text{ft}^{2}/\text{day} \\ F(n) = & 2.6532 \end{array}$

available time to achieve desired degree of consolidation U_h average degree of consolidation due to horizontal drainage coefficient of consolidation for horizontal drainage drain spacing factor

where,

 $F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$ (simplified) (See FHWA eq. 3)

diameter of an equivalent circular drain (See FHWA eq. 9)

 $d_w = 2(a+b)/\pi$ $d_w = 0.23 \text{ ft}$

0.20 /1

D = 6.781017 ft

required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: 6.00 ft

Length Outer Edge of Equilateral Triangle (or square) =	1365.79 ft
Number Drain Spaces Along Outer Edge =	227.60 ea
Total number wick drains =	26243 ea
Total linear feet wick drain =	813533 lf
Estimated total cost =	\$406,766.50

COMPUTATIONS

SCENARIO 1

OPTION 2

Job No. 79784 HDR Computation Computed Project SCI-823 Portsmouth Bypass

Store	4 EO% Conco	lidation					
V	Stage 1 - 50% Consolidation						
	riangular Patte						
t (days)	Spacing (ft)	Cost (\$)					
30	3.28	522,067					
60	4.71	254,641					
90	5.87	164,938					
120	6.79	123,965					
150	7.49	101,943					
180	8.05	88,611					
210	8.51	79,466					
240	8.95	71,890					
270	9.46	64,474					
300	10.14	56,306					

Subject

Task



Stage	Stage 2 - 90% Consolidation					
Т	riangular Patte	rn				
t (days)	Spacing (ft)	Cost (\$)				
30	2.33					
60	2.99					
90	3.60					
120	4.17					
150	4.70					
180	5.18					
210	5.62					
240	6.02					
270	6.39					
300	6.71					
330	7.01					

Total Time					
Triangu	lar Pattern				
t (days)	Spacing (ft)				
92	3.00				
151	4.00				
230	5.00				
332	6.00				
461	7.00				

12.00 10.00 8.00 6.00 4.00 2.00 0.00 30 60 90 120 150 180 210 240 270 300 330 360 390 420 Time (days)



Consolidation Time vs. Minimum Drain Spacing

19415

4/17/2008

5/1/2008

1

PID No.

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79784

PID No.

HDR Computation

HR

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

- 1. Federal Highway Administration, "Prefabricated Vertical Drains A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
- 2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
- 3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
- 4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Lucasville-Minford Road (CR 28) (DLZ, 2008)

Assumptions:

- 1. Terzaghi's one-dimensional consolidation theory applies.
- 2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
- 3. Effect of disturbance related to soil displacement during installation is negligible.
- 4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	211,055	sf	Total area along Ramps A, B, C and D at CR 28 Interchange to be drained (DLZ, 2008)
C =	\$0.50	cost/lf	Material + Installation Cost
8	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	94	day	available time to achieve desired degree of consolidation U _h
H =	43.5	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c _v =	0.081	ft²/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c _h =	0.0972	ft²/day	coefficient consolidation for horizontal drainage
	Note:		
	General Ca	ise: c _h =	1.2 to 1.5*c _v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: ch = up to 10*cv

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$
 (See FHWA eq. 1)

where,

Calcul

U = overall average degree of consolidation

- U_h = average degree of consolidation due to horizontal (or radial) drainage
- U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

$U_{h} = 0 \%$	4			
Uv = 50 %	t =	4585	days	Need to Consider Other Options.
$U = U_v = 50 \%$				
$T_v = 0.19625$				
ulate U _v that will occur in design period of t. t = 94 day $T = \frac{tC_v}{H^2}$				
T = 0.00				

Calculate required U_h

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$
(S)
U_h = 0.46

ee FHWA eq. 1)

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

Job No.

79784

PID No.

ft

19415

$$t = \frac{D^2}{8c_h} F(n) \ln \left[\frac{1}{1 - \overline{U}_h} \right]$$

(See FHWA eq. 8)

1

where,

 $\begin{array}{rll} t = & 94 \ day \\ \overline{U}_{h} = & 0.46 \\ c_{h} = & 0.0972 \ ft^{2}/day \\ F(n) = & 2.654141 \end{array}$

available time to achieve desired degree of consolidation U_h average degree of consolidation due to horizontal drainage coefficient of consolidation for horizontal drainage drain spacing factor

where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$
 (simplified) (See FHWA eq. 3)

 $d_w = 2(a+b)/\pi$ $d_w = 0.23 \text{ ft}$ diameter of an equivalent circular drain (See FHWA eq. 9)

D = 6.787405 ft

required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



influence to achieve primary consolidation within given design period: 6.01 Length Outer Edge of Equilateral Triangle (or square) = 698.15 ft Number Drain Spaces Along Outer Edge = 116.23 ea Total number wick drains ≈ 6931 ea Total linear feet wick drain = 315361 lf Estimated total cost ≈ \$157,680.25

Job No. 79784 PID No.

19415

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Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/17/2008
Subject	CR 28 Interchange: Mainline Sta 520+00 to Sta 537+00	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	1

Stage 1 - 50% Consolidation								
T	Triangular Pattern							
t (days)	Spacing (ft)	Cost (\$)						
30	3.28	861,383						
60	4.71	419,556						
90	5.87	271,453						
120	6.79	203,863						
150	7.49	167,531						
180	8.05	145,532						
210	8.51	130,471						
240	8.95	117,959						
270	9.46	105,765						
300	10.14	92,320						





Total Time						
Triangu	Triangular Pattern					
t (days)	Spacing (ft)					
92	3.00					
151	4.00					
230	5.00					
332	6.00					
461	7.00					

Consolidation Time vs. Minimum Drain Spacing



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Job No.

HDR Computation

19415

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

- 1. Federal Highway Administration, "Prefabricated Vertical Drains A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
- 2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
- 3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
- 4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Lucasville-Minford Road (CR 28) (DLZ, 2008)

Assumptions:

- 1. Terzaghi's one-dimensional consolidation theory applies.
- 2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
- 3. Effect of disturbance related to soil displacement during installation is negligible.
- 4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	349,313	sf	Total area along Mainline Sta 520+00 to Sta 537+00 at CR 28 Interchange to be drained (DLZ, 2008)
C =	\$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	128	day	available time to achieve desired degree of consolidation U_{h}
H =	43.5	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c _v =	0.081	ft²/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c _h =	0.0972	ft²/day	coefficient consolidation for horizontal drainage
1	Note:		
	General Ca	ISE: Ch =	1.2 to 1.5*c,

General Case: c_h = 1.2 to 1.5°c_v

-If layering of silt and sand in discontinuous lenses is evident: ch = 2 to 4*cv

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: ch = up to 10*cv

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$
 (See FHWA eq. 1)

where,

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

0.08

U _h =	0	%					
Uv =	50	%		t =	4585	days	Need to Consider Other Options.
$U = U_v =$	50	%					enconcentrations - Excert rescue server prove the context of a more strategy and
T _v =	0.19625						
Calculate U_v that $t = T = T$		n design pe day	eriod of t.				
T _v =	0.01						

 $U_v =$

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$
 (See FHWA eq. 1)

$$U_h = 0.45$$

\bigcirc	Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
	Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
	Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

Job No.

79784

PID No.

19415

$$t = \frac{D^2}{8c_h} F(n) \ln \left[\frac{1}{1 - \overline{U}_h}\right]$$

(See FHWA eq. 8)

where,

 $\begin{array}{rll} t = & 128 \mbox{ day} \\ \overline{U}_h = & 0.45 \\ c_h = & 0.0972 \mbox{ ft}^2/\mbox{ day} \\ F(n) = & 2.806234 \end{array}$

available time to achieve desired degree of consolidation U_h average degree of consolidation due to horizontal drainage coefficient of consolidation for horizontal drainage drain spacing factor

where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$
 (simplified) (See FHWA eq. 3)

 $d_w = 2(a+b)/\pi$ $d_w = 0.23$

b)/π diameter of an equivalent circular drain (See FHWA eq. 9)
 0.23 ft

D = 7.902355 ft

required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.





Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/17/2008
Subject	Shumway Hollow Road (TR 234) Interchange: Area #3 (Ramp D Area)	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	1

Job No.

Stage 1					
Т	riangular Patte	ern			
t (days)	Spacing (ft)	Cost (\$)			
30	2.15	3,289,069			
60	2.65	2,158,592			
90	3.13	1,545,784			
120	3.59	1,177,086			
150	4.03	937,347			
180	4.44	772,303			
210	4.83	653,930			
240	5.19	565,905			
270	5.53	498,775			
300	5.85	446,555			
330	6.15	404,597			
360	6.42	370,900			
390	6.68	343,263			
420	6.92	320,106			

Stage 1 Consolidation Time vs. Cost
3,500,000
3,000,000
2,500,000
9 2,000,000 9 1,500,000
8 1,500,000
1,000,000
500,000
0 +
30 60 90 120 150 180 210 240 270 300 330 360 390 420
Time (days)

79784



Total Time						
Triangu	Triangular Pattern					
t (days)	Spacing (ft)					
142	3.00					
256	4.00					
386	5.00					
545	6.00					
744	7.00					





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-Stage 1 - Stage 2

19415

PID No.

Job No.

79784

HDR Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.

2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.

- 3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
- 4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

- 1. Terzaghi's one-dimensional consolidation theory applies.
- 2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
- 3. Effect of disturbance related to soil displacement during installation is negligible.
- 4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	842,862	sf	Total Area #3 (Ramp D Area) to be drained (DLZ, 2008)
C =	\$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	225	day	available time to achieve desired degree of consolidation U _h
H =	29	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833		thickness of drain (Assume for 4" wide x 1/4" thick)
c _v =	0.081	ft²/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c _h =	0.0972	ft²/day	coefficient consolidation for horizontal drainage
1	Note:		
	Conoral C		

-General Case: c_h = 1.2 to 1.5*c_v

-If layering of silt and sand in discontinuous lenses is evident: $c_h = 2$ to 4^*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: ch = up to 10*cv

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1 - (1 - \overline{U}_{h})(1 - \overline{U}_{v})$$
 (See FHWA eq. 1)

where,

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U _h =	0 %				
Uv =	90 %	t =	8805	days	Need to Consider Other Options.
$U = U_v =$	90 %				
T _v =	0.848				
ate U _v that wi	ll occur in design period of	t.			
t =	225 day				

Calcula

$$T = \frac{tc_v}{H^2}$$
$$T_v = 0.02$$
$$U_v = 0.17$$

Calculate required U_h

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$
 (See FHWA eq. 1)
U_h = 0.88

Job No.	79784	PID No.	19415
JOD NO.	13104	FID 190.	19413

Project	SCI-823 Portsmouth Bypass	Computed	_JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

$$t = \frac{D^2}{8c_h} F(n) \ln \left[\frac{1}{1 - \overline{U}_h}\right]$$

(See FHWA eq. 8)

where,

 $\begin{array}{rl} t = & 225 \text{ day} \\ \overline{U}_{h} = & 0.88 \\ c_{h} = & 0.0972 \text{ ft}^{2}/\text{day} \\ F(n) = & 2.473098 \end{array}$

available time to achieve desired degree of consolidation U_h average degree of consolidation due to horizontal drainage coefficient of consolidation for horizontal drainage drain spacing factor

where,

 $F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$ (simplified) (See FHWA eq. 3)

 $d_w = 2(a+b)/\pi$ $d_w = 0.23 \text{ ft}$

diameter of an equivalent circular drain (See FHWA eq. 9)

D = 5.663406 ft

required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.





Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/17/2008
Subject	Shumway Hollow Road (TR 234) Interchange: Areas #1 & #2	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	1

Job No.

Stage 1					
Triangular Pattern					
t (days)	Spacing (ft)	Cost (\$)			
· 30	2.15	3,152,282			
60	2.65	2,068,878			
90	3.13	1,481,568			
120	3.59	1,128,214			
150	4.03	898,442			
180	4.44	740,265			
210	4.83	626,805			
240	5.19	542,454			
270	5.53	478,113			
300	5.85	428,064			
330	6.15	387,841			
360	6.42	355,555			
390	6.68	329,065			
420	6.92	306,869			

3,000,000	t				
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1,000,000					
500,000			·		
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Total Time				
Triangular Pattern				
t (days)	Spacing (ft)			
142	3.00			
256	4.00			
386	5.00			
545	6.00			
744	7.00			





79784

HX

PID No.

Job No. 79784

PID No.

HDR Computation

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Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

- 1. Federal Highway Administration, "Prefabricated Vertical Drains A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
- 2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
- 3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
- 4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

- 1. Terzaghi's one-dimensional consolidation theory applies.
- 2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
- 3. Effect of disturbance related to soil displacement during installation is negligible.
- 4. Drain has infinite permeability (i.e. no drain resistance).

Input Values:

A =	807,730	sf	Total Areas #1 & #2 to be drained (DLZ, 2008)
C =	\$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	315	day	available time to achieve desired degree of consolidation U _h
H =	29	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833		thickness of drain (Assume for 4" wide x 1/4" thick)
c _v =	0.081	ft²/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c _h =	0.0972	ft²/day	coefficient consolidation for horizontal drainage
	Note:		
12	Ganaral Ca		12 to 15*0

-General Case: c_h = 1.2 to 1.5*c_v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to $4^{\star}c_{\nu}$

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: $c_h = up$ to $10^* c_v$

Design Equations:

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1 - (1 - \overline{U}_{h})(1 - \overline{U}_{v})$$
 (See FHWA eq. 1)

where,

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

 U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U _h =	0 %				
Uv =	90 %	t =	8805	days	Need to Consider Other Options.
$U = U_v =$	90 %				service encloses and a state of the state of the service of the se
T _v =	0.848				
t = T	Il occur in design period of t 315 day $\frac{tc_v}{H^2}$				
Τ _v =	0.03				

 $U_{v} = 0.20$

Calculate required Uh

$$\overline{U} = 1 - (1 - \overline{U}_{h})(1 - \overline{U}_{v})$$
 (See FHWA eq. 1)

$$U_{h} = 0.88$$

Job No.	79784	PID No.	19415

 Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

$$t = \frac{D^2}{8c_h} F(n) \ln \left[\frac{1}{1 - \overline{U}_h}\right]$$

(See FHWA eq. 8)

where,

 $\begin{array}{rll} t = & 315 \ \text{day} \\ \overline{U}_{h} = & 0.88 \\ c_{h} = & 0.0972 \ \text{ft}^{2}/\text{day} \\ F(n) = & 2.6532 \end{array}$

available time to achieve desired degree of consolidation U_h average degree of consolidation due to horizontal drainage coefficient of consolidation for horizontal drainage drain spacing factor

where,

 $F(n) = \ln \left(\frac{D}{d_w}\right) - 0.75$ (simplified) (See FHWA eq. 3)

 $d_w = 2(a+b)/\pi$ $d_w = 0.23 \text{ ft}$ diameter of an equivalent circular drain (See FHWA eq. 9)

D = 6.781017 ft

required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.





Length Outer Edge of Equilateral Triangle (or square) =	1365.79 ft
Number Drain Spaces Along Outer Edge =	227.60 ea
Total number wick drains =	26243 ea
Total linear feet wick drain =	813533 lf
Estimated total cost =	\$406,766.50

CONCEPTUALIZED CONSTRUCTION SCHEDULE

\cap																							F	IRS	т сс	ONST	RU	СТІС	ON S	EAS	SON								
WEEK	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	81	9 :	20	21	22	23	24	25	26	27	28	29	3	03	1 3	32	33	34	35	36	37
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STAGE 1 CONSTRUCTION							_																						_										<u> </u>
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CONCEPTUALIZED CONSTRUCTION SCHEDULE

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CONCEPTUALIZED CONSTRUCTION SCHEDULE

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CONCEPTUALIZED CONSTRUCTION SCHEDULE

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<u>Scenario 2</u> – At both the Shumway Hollow and Lucasville-Minford Interchanges, Ramps A and D will be paved and opened to traffic. The wick drains will be spaced evenly at each interchange.

*Option 1:* Total Cost = \$4,275,931

- Wick drains at Shumway Hollow Interchange as well as the mainline embankment from Sta. 352+00 to Sta. 415+00 spaced at 5 feet.
- All wick drains at 7-foot spacing across the Lucasville-Minford Interchange.
- Complete embankments in 2 construction seasons.
- Reach 90% consolidation of entire Shumway Hollow Interchange including Mainline Embankment Sta. 352+00 to Sta. 415+00 in second construction season.
- Reach 90% consolidation of entire Lucasville-Minford Interchange including Mainline Embankment Sta. 520+00 to Sta. 537+00 in third construction season.

### Constructability Benefits/Issues with Option 1

- Paving at Shumway Hollow Interchange could begin at the beginning of the third construction season.
- Paving at the Lucasville-Minford Interchange could begin approximately 23 weeks into the third construction season.

### *Option 2:* Total Cost = \$4,383,857

- Wick drains at Shumway Hollow Interchange as well as the mainline embankment from Sta. 352+00 to Sta. 415+00 spaced at 5 feet.
- All wick drains at 6-foot spacing across the Lucasville-Minford Interchange.
- Complete embankments in 2 construction seasons.
- Reach 90% consolidation of all embankments at both interchanges in 2 construction seasons.

### Constructability Benefits/Issues with Option 2

• Allow paving to begin from either intersection at beginning of third construction season.

# COMPUTATIONS

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SCENARIO 2

OPTION 1
Job No.

19415

# HR

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/17/2008
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	1

Stage	1 - 50% Consol	lidation
Т	riangular Patte	rn
t (days)	Spacing (ft)	· Cost (\$)
30	3.28	1,378,650
60	4.71	670,829
90	5.87	433,683
120	6.79	325,507
150	7.49	267,358
180	8.05	232,164
210	8.51	208,049
240	8.95	188,074
270	9.46	168,555
300	10.14	147,056



79784



Tot	al Time
Triangu	ılar Pattern
t (days)	Spacing (ft)
92	3.00
151	4.00
230	5.00
332	6.00
461	7.00

Consolidation Time vs. Minimum Drain Spacing





Job No.

79784

PID No.

# HR

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

**References:** 

- 1. Federal Highway Administration, "Prefabricated Vertical Drains A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
- 2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
- Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
   SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

#### Assumptions:

- 1. Terzaghi's one-dimensional consolidation theory applies.
- 2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
- 3. Effect of disturbance related to soil displacement during installation is negligible.
- 4. Drain has infinite permeability (i.e. no drain resistance).

#### Input Values:

A =	560,368 sf	Total area to be drained (DLZ, 2008)
C =	\$0.50 cost/lf	Material + Installation Cost
	Single	Vertical Drainage (Single or Double)
0000	Triangular	Wick Drain Pattern
t =	128 day	available time to achieve desired degree of consolidation U _h
H =	43.5 ft	height of compressible layer
a =	0.33333 ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833 ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c _v =	0.081 ft ² /day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c _h =	0.0972 ft ² /day	coefficient consolidation for horizontal drainage
1	Note:	
	General Case: c _h =	1.2 to 1.5*c _v

-If layering of silt and sand in discontinuous lenses is evident: ch = 2 to 4*cv

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10⁺c_v

#### **Design Equations:**

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1 - (1 - \overline{U}_{h})(1 - \overline{U}_{v})$$
 (See FHWA eq. 1)

where,

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

 $U_v$  = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

 $U_h =$ 0 % Need to Consider Other Options. Uv = 50 % t = 4585 days  $U = U_v =$ 50 % 0.19625 T_v = Calculate U_v that will occur in design period of t. t = 128 day  $T = \frac{tc_v}{H^2}$ 0.01  $T_v =$  $U_v =$ 0.08

Calculate required U_h

$$\overline{\overline{U}} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$
(Se  
U_h = 0.45

See FHWA eq. 1)

Job No.	79784	PID No.	19415

	Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Ŀ	Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
ŀ	Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

$$t = \frac{D^2}{8c_h} F(n) \ln \left[ \frac{1}{1 - \overline{U_h}} \right]$$

(See FHWA eq. 8)

where,

t = 128 day  $\overline{U}_{h} =$ 0.45 0.0972 ft²/day  $c_h =$ F(n) =2.806234

available time to achieve desired degree of consolidation Uh average degree of consolidation due to horizontal drainage coefficient of consolidation for horizontal drainage drain spacing factor

where,

$$F(n) = \ln \left(\frac{D}{d_w}\right) - 0.75$$
 (simplified) (See FHWA eq. 3)

 $d_w = 2(a+b)/\pi$ 

diameter of an equivalent circular drain (See FHWA eq. 9)

d_w ≍ 0.23 ft

D = 7.902355 ft

required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: 6.99 ft Length Outer Edge of Equilateral Triangle (or square) = 1137.59 ft Number Drain Spaces Along Outer Edge = 162.67 ea

Hamber Brain epageer keing eater Eage	102.01 00
Total number wick drains =	13476 ea
Total linear feet wick drain =	613158 lf
Estimated total cost =	\$306.579.00

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	φ000,010.00

Job No. 79784

19415

# HR

	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	1

	Stage 1	
Т	riangular Patte	rn
t (days)	Spacing (ft)	Cost (\$)
30	2.15	6,432,578
60	2.65	4,220,356
90	3.13	3,021,322
120	3.59	2,300,045
150	4.03	1,831,093
180	4.44	1,508,305
210	4.83	1,276,813
240	5.19	1,104,716
270	5.53	973,478
300	5.85	871,379
330	6.15	789,369
360	6.42	723,509
390	6.68	669,492
420	6.92	624,232







	Stage 2				
T	riangular Patte	m			
t (days)	Spacing (ft)	Cost (\$)			
30	2.34				
60	3.01				
90	3.64				
120	4.23				
150	4.77				
180	5.27				
210	5.72				
240	6.14				
270	6.51				
300	6.85				
330	7.15				

Total Time				
Triangular Pattern				
t (days)	Spacing (ft)			
142	3.00			
256	4.00			
386	5.00			
545	6.00			
744	7.00			

Job No.

79784

# **HDR Computation**

19415

)	Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
	Subject	Shumway Hollow Road (TR 234) Interchange	Checked	DMV	Date	5/1/2008
	Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.

2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.

- 3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
- 4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

- 1. Terzaghi's one-dimensional consolidation theory applies.
- 2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
- 3. Effect of disturbance related to soil displacement during installation is negligible.
- 4. Drain has infinite permeability (i.e. no drain resistance).

#### **Input Values:**

A =	1,650,592 sf	Total area to be drained (DLZ, 2008)
C =	\$0.50 cost/lf	Material + Installation Cost
	Single	Vertical Drainage (Single or Double)
	Triangular	Wick Drain Pattern
t =	225 day	available time to achieve desired degree of consolidation U _h
H =	29 ft	height of compressible layer
a =	0.33333 ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833 ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c _v =	0.081 ft ² /day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c _h =	0.0972 ft ² /day	coefficient consolidation for horizontal drainage
	Note:	
-	General Case: c =	1 2 to 1 5*c

-General Case: c_h = 1.2 to 1.5*c_v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

#### **Design Equations:**

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$
 (See FHWA eq. 1)

where,

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

 $U_v$  = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U _h =	0 %				
Uv =	90 %	t =	8805	days	Need to Consider Other Options.
$U = U_v =$	90 %				
T _v =	0.848				
ate U _v that wi	ill occur in design period of t.				
t =	225 day				

Calcula

$$T = \frac{tc_v}{H^2}$$
$$T_v = 0.02$$
$$U_v = 0.17$$

Calculate required U_h

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$
 (See FHWA eq. 1)  

$$U_h = 0.88$$

				Job No.	79784		PID No.	19415
	HDF	R Computatio	on					
C	Project	SCI-823 Portsmouth Bypa	SS		Computed	JSA	Date	4/8/2008
	Subject	Shumway Hollow Road (T	R 234) Interchange		Checked	DMV	Date	5/1/2008
	Task	Wick Drain Analyses - Idea	alized Case		Sheet	2	Of	2
	t = whe	$8c_h + [1-O_h]$ ere, t = 225  day $\overline{U}_h = 0.88$ $c_h = 0.0972 \text{ ft}^2/\text{day}$ F(n) = 2.473098 where,	(See FHWA eq. 8) available time to achieve desi average degree of consolidati coefficient of consolidation for drain spacing factor	ion due to horizontal dra r horizontal drainage	ainage			
		F	$(n) = \ln\left(\frac{D}{d_w}\right) - 0.75  (n) = 100$	simplified) (See FH	IWA eq. 3)			

 $d_w = 2(a+b)/\pi$  $d_w = 0.23$  ft diameter of an equivalent circular drain (See FHWA eq. 9)

D = 5.663406 ft

required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.





COMPUTATIONS

SCENARIO 2

**OPTION 2** 

JobNo.

79784

# HR

PID No.

Ĵ	Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/17/2008
	Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
	Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	1

Stage 1 - 50% Consolidation						
Triangular Pattern						
t (days)	Cost (\$)					
30	3.28	1,378,650				
60	4.71	670,829				
90	5.87	433,683				
120	6.79	325,507				
150	7.49	267,358				
180	8.05	232,164				
210	8.51	208,049				
240	8.95	188,074				
270	9.46	168,555				
300	10.14	147,056				





Total Time				
Triangular Pattern				
t (days)	Spacing (ft)			
92	3.00			
15 <b>1</b>	4.00			
230	5.00			
332	6.00			
461	7.00			

Consolidation Time vs. Minimum Drain Spacing



Job No.

79784

# HDR Computation

PID No.

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

**References:** 

- 1. Federal Highway Administration, "Prefabricated Vertical Drains A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
- 2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
- 3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
- 4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

#### Assumptions:

- 1. Terzaghi's one-dimensional consolidation theory applies.
- 2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
- 3. Effect of disturbance related to soil displacement during installation is negligible.
- 4. Drain has infinite permeability (i.e. no drain resistance).

#### Input Values:

A =	560,368 sf	Total area to be drained (DLZ, 2008)	
C =	\$0.50 cost/lf	Material + Installation Cost	
	Single	Vertical Drainage (Single or Double)	
	Triangular	Wick Drain Pattern	
t =	94 day	available time to achieve desired degree of consolidation U _h	
H =	43.5 ft	height of compressible layer	
a =	0.33333 ft	width of drain (Assume 4" wide x 1/4" thick)	
b =	0.020833 ft	thickness of drain (Assume for 4" wide x 1/4" thick)	
c _v =	0.081 ft ² /day	<ul> <li>coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 &amp; B-2)</li> </ul>	
c _h =	0.0972 ft ² /day	coefficient consolidation for horizontal drainage	
-	Note:		
	-General Case: c _h	$= 1.2 \text{ to } 1.5^{*} c_{v}$	

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: ch = up to 10*cv

#### **Design Equations:**

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1 - (1 - \overline{U}_{h})(1 - \overline{U}_{n})$$
 (See FHWA eq. 1)

where,

U = overall average degree of consolidation

U_b = average degree of consolidation due to horizontal (or radial) drainage

U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

0 %  $U_h =$ Uv = 50 % 4585 Need to Consider Other Options. t = days  $U = U_v =$ 50 %  $T_v =$ 0.19625 Calculate U_v that will occur in design period of t. t = 94 day

$$T = \frac{tc_v}{H^2}$$
$$T_v = 0.00$$
$$U_v = 0.07$$

Calculate required U_h

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$
 (See U_h = 0.46

FHWA eq. 1)

19415

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

Job No.

$$t = \frac{D^2}{8c_h} F(n) \ln \left[ \frac{1}{1 - \overline{U}_h} \right]$$

(See FHWA eq. 8)

where,

 $\begin{array}{rcl} t = & 94 \ \text{day} \\ \overline{U}_{h} = & 0.46 \\ c_{h} = & 0.0972 \ \text{ft}^{2}/\text{day} \\ F(n) = & 2.654141 \end{array}$ 

available time to achieve desired degree of consolidation  $U_h$ average degree of consolidation due to horizontal drainage coefficient of consolidation for horizontal drainage drain spacing factor

where,

 $F(n) = \ln \left( \frac{D}{d_w} \right) - 0.75$  (simplified) (See FHWA eq. 3)

 $d_w = 2(a+b)/\pi$ 

diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

D = 6.787405 ft

required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.

79784





PID No.

Job No. 79784

PID No.

# HR

19415

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	1

	Stage 1	
T	riangular Patte	rn
t (days)	Spacing (ft)	Cost (\$)
30	2.15	6,432,578
60	2.65	4,220,356
90	3.13	3,021,322
120	3.59	2,300,045
150	4.03	1,831,093
180	4.44	1,508,305
210	4.83	1,276,813
240	5.19	1,104,716
270	5.53	973,478
300	5.85	871,379
330	6.15	789,369
360	6.42	723,509
390	6.68	669,492
420	6.92	624,232



	Stage 2	
Т	riangular Patte	rn
t (days)	Spacing (ft)	Cost (\$)
30	2.34	
60	3.01	
90	3.64	
120	4.23	
150	4.77	
180	5.27	
210	5.72	
240	6.14	
270	6.51	
300	6.85	
330	7.15	

Tota	al Time
Triangu	ılar Pattern
t (days)	Spacing (ft)
142	3.00
256	4.00
386	5.00
545	6.00
744	7.00





Job No.

79784

# **HDR** Computation

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

- 1. Federal Highway Administration, "Prefabricated Vertical Drains A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
- 2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
- 3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
- 4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

- 1. Terzaghi's one-dimensional consolidation theory applies.
- 2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
- 3. Effect of disturbance related to soil displacement during installation is negligible.
- 4. Drain has infinite permeability (i.e. no drain resistance).

#### Input Values:

A =	1,650,592	sf	Total area to be drained (DLZ, 2008)
C =	\$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	225	day	available time to achieve desired degree of consolidation U _h
H =	29	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833		thickness of drain (Assume for 4" wide x 1/4" thick)
c _v =	0.081	ft²/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c _h =	0.0972	ft²/day	coefficient consolidation for horizontal drainage
1	Note:		
1	-General Ca	ase: c _h =	1.2 to 1.5*c.

General Case:  $C_h = 1.2$  to  $1.5^{\circ}C_v$ 

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers:  $c_h = up$  to  $10^{+}c_v$ 

#### **Design Equations:**

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1 - (1 - \overline{U}_{h})(1 - \overline{U}_{v})$$
 (See FHWA eq. 1)

where,

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

$U_h =$	0 %				
Uv =	90 %	t =	8805	days	Need to Consider Other Options.
$U = U_v =$	90 %				
T _v =	0.848				
ate U _v that wil	ll occur in design period of t.				
t =	225 day				
T	tc,				

Calcula

$$T = \frac{tc_v}{H^2}$$
$$T_v = 0.02$$
$$U_v = 0.17$$

Calculate required U_h

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$
$$U_h = 0.88$$

(See FHWA eq. 1)

			Job No.	79784		PID No.	19415
HDF	R Computatio	on					
	SCI-823 Portsmouth Bypa	SS		Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (T	R 234) Interchange		Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idea	alized Case		Sheet	2	Of	2
t = whe	$= \frac{D^2}{8c_h} F(n) \ln \left[ \frac{1}{1 - \overline{U}_h} \right]$ ere, $t = 225 \text{ day}$ $\overline{U}_h = 0.88$ $c_h = 0.0972 \text{ ft}^2/\text{day}$ $F(n) = 2.473098$	(See FHWA eq. 8) available time to achieve desir- average degree of consolidation coefficient of consolidation for drain spacing factor	on due to hori:	zontal drainage			
• 、	where, F	$u(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$ (s	implified)	(See FHWA eq. 3)			
	$d_w = 2(a+b)/\pi$	diameter of an equivalent circu	ılar drain (See	FHWA eq. 9)			

D = 5.663406 ft

0.23 ft

 $d_w =$ 

required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.





## CONCEPTUALIZED CONSTRUCTION SCHEDULE

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# CONCEPTUALIZED CONSTRUCTION SCHEDULE

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TR234 Ramp C								1							_	_	_	_	_	_	_	_	_		_									OR 5				
TR234 Ramp D TR234							_										_		_				_											OR 5				
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Scenario 3 – Shumway Hollow Interchange Ramps A & D will be paved and opened to traffic. Additional time allowed for consolidation of embankment south of Shumway Hollow Road (TR 234), as this area will not be open to traffic. At Lucasville-Minford Interchange, Ramps A & D will be opened to traffic.

#### Option 1: Total Cost = \$4,199,857

- Wick drains along the mainline embankment from Sta. 384+00 to Sta. 415+00 and at TR 234 Ramps A & D spaced at 5 feet.
- Wick drains along the mainline embankment from Sta. 352+00 to Sta. 384+00 and at TR 234 Ramps B & C spaced at 6 feet.
- Wick drains at 7 foot spacing across the Lucasville-Minford Interchange.
- Complete embankments in 2 construction seasons.
- Reach 90% consolidation of Shumway Hollow Interchange north of TR 234 (i.e. TR 234 Ramps A & D and Mainline Embankment from Sta. 384+00 to Sta. 415+00) in second construction season.
- Reach 90% consolidation of Shumway Hollow Interchange south of TR 234 (i.e. TR 234 Ramps B & C and Mainline Embankment from Sta. 352+00 to 384+00) and the Lucasville-Minford Interchange in third construction season.

#### Constructability Benefits/Issues with Option 1

- Paving to begin at north end of Shumway Hollow Interchange at beginning of third construction season.
- Paving at south end of Shumway Hollow Interchange could begin approximately 9 weeks into the third construction season.
- Paving at Lucasville-Minford Interchange could begin approximately 23 weeks into third construction season.

Option 2: Total Cost = \$4,243,014

- Wick drains at Shumway Hollow Interchange along the Mainline Embankment from Sta. 384+00 to Sta. 415+00 and at TR 234 Ramps A & D spaced at 5 feet.
- Wick drains at Shumway Hollow Interchange along the Mainline Embankment from Sta. 352+00 to Sta. 384+00 and at TR 234 Ramps B & C spaced at 6 feet.
- Wick drains at Lucasville-Minford Interchange along Ramps A, B, C and D spaced at 6 feet.
- Wick drains at Lucasville-Minford Interchange along the mainline Embankment from Sta. 520+00 to Sta. 537+00 spaced at 7 feet.
- Complete construction of all embankments in 2 construction seasons.
- Reach 90% consolidation of North Shumway Hollow Interchange (i.e. TR 234 Ramps A & D and Mainline Embankment from Sta. 384+00 to Sta. 415+00) in second construction season.

- Reach 90% consolidation of South Shumway Hollow Interchange (i.e. TR234 Ramps B & C and Mainline Embankment from Sta. 352+00 to 384+00) in third construction season.
- Reach 90% consolidation of Ramps A, B, C and D at Lucasville-Minford Interchange in second construction season.
- Reach 90% consolidation of Mainline Embankment from Sta. 520+00 to Sta. 537+00 at Lucasville-Minford Interchange in third construction season.

#### Constructability Benefits/Issues with Option 2

- Paving at the North end of the Shumway Hollow Interchange could begin at the beginning of the third construction season.
- Paving at South end of Shumway Hollow Interchange could begin approximately 9 weeks into the third construction season.
- Paving along ramps A, B, C, and D at the Lucasville-Minford Interchange could begin at the beginning of the third construction season.
- Paving along the mainline at the Lucasville-Minford Interchange could begin approximately 23 weeks inot the third construction season.

# COMPUTATIONS

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**SCENARIO 3** 

**OPTION 1** 

Job No. 79784

#### 19415

# HR

	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/17/2008
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	1

Stage	1 - 50% Conso	lidation
	riangular Patte	
t (days)	Spacing (ft)	Cost (\$)
30	3.28	1,378,650
60	4.71	670,829
90	5.87	433,683
120	6.79	325,507
150	7.49	267,358
180	8.05	232,164
210	8.51	208,049
240	8.95	188,074
270	9.46	168,555
300	10.14	147,056





Tot	al Time
Triangu	ılar Pattern
t (days)	Spacing (ft)
92	3.00
151	4.00
230	5.00
332	6.00
461	7.00

Consolidation Time vs. Minimum Drain Spacing 12.00 10.00 8.00 6.00 4.00 2.00 0.0030 60 90 120 150 180 210 240 270 300 330 360 390 420





Job No.

79784

# HR

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

**References:** 

- 1. Federal Highway Administration, "Prefabricated Vertical Drains A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
- 2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
- Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
   SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)
- Assumptions:
- 1. Terzaghi's one-dimensional consolidation theory applies.
- 2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
- 3. Effect of disturbance related to soil displacement during installation is negligible.
- 4. Drain has infinite permeability (i.e. no drain resistance).

#### Input Values:

A =	560,368 sf	Total ramp area at CR 28 Interchange to be drained (DLZ, 2008)
C =	\$0.50 cost/lf	Material + Installation Cost
	Single	Vertical Drainage (Single or Double)
	Triangular	Wick Drain Pattern
t =	128 day	available time to achieve desired degree of consolidation U _h
H =	43.5 ft	height of compressible layer
a =	0.33333 ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833 ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c _v =	0.081 ft ² /day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c _h =	0.0972 ft ² /day	coefficient consolidation for horizontal drainage
1	Note:	
	General Case: ch =	1.2 to 1.5*c,

General Case:  $c_h = 1.2$  to  $1.5 °c_v$ 

-If layering of silt and sand in discontinuous lenses is evident:  $c_{\rm h}$  = 2 to  $4^{*}c_{\rm v}$ 

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

#### **Design Equations:**

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$
 (See FHWA eq. 1)

where,

Calcula

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

0.01

0.08

	0.0/					
U _h =	0 %					
Uv =	50 %		t =	4585	days	Need to Consider Other Options.
$U = U_v =$	50 %					
T _v =	0.19625					
ate U _v that v t = T =	will occur in design provide the second sec	eriod of t.				

T_v = U_v =

$$\overline{U} = 1 - (1 - \overline{U}_{h})(1 - \overline{U}_{v})$$
 (See FHWA eq. 1)  
U_h = 0.45

Project	SCI-823 Portsmouth Bypa	SS	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange		Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Ide	alized Case	Sheet	2	Of	2
	$= \frac{D^2}{8c_h} F(n) \ln \left[ \frac{1}{1 - \overline{U}_h} \right]$ here, $\frac{t = 128 \text{ day}}{\overline{U}_h = 0.45}$ $c_h = 0.0972 \text{ ft}^2/\text{day}$ $F(n) = 2.806234$ where,	(See FHWA eq. 8) available time to achieve desired degree of consolid average degree of consolidation due to horizontal due coefficient of consolidation for horizontal drainage drain spacing factor	rainage			
	F	$V(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$ (simplified) (See Fi	HWA eq. 3)			
	$d_w = 2(a+b)/\pi$ $d_w = 0.23 \text{ ft}$	diameter of an equivalent circular drain (See FHWA	eq. 9)			
	D ≔ 7.902355 ft	required diameter of the cylinder of influence of the within given design period.	drain (drain influ	ience zone) to	achieve con	solidation
$\bigcirc$		Diameter vs. Consolidation	Time			

79784

Job No.



Optimum Drain Spacing based on required diameter of cyliner of influence to achieve primary consolidation within given design period: 6.99 ft Length Outer Edge of Equilateral Triangle (or square) = 1137.59 ft Number Drain Spaces Along Outer Edge = 162.67 ea Total number wick drains = 13476 ea Total linear feet wick drain = 613158 lf Estimated total cost = \$306,579.00 19415

PID No.

# Job No. 79784 PID No. HDR Computation Computed JSA Date

		Compoted	004	Date	4/11/2000
Subject	Shumway Hollow Road (TR 234) Interchange: North Area	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	11	Of	

	Stage 1	
Т	riangular Patte	rn
t (days)	Spacing (ft)	Cost (\$)
30	2,15	5,013,754
60	2.65	3,289,813
90	3.13	2,355,380
120	3.59	1,793,257
150	4.03	1,427,767
180	4.44	1,176,171
210	4.83	995,736
240	5.19	861,583
270	5.53	759,283
300	5.85	679,691
330	6.15	615,769
360	6.42	564,417
390	6.68	522,304
420	6.92	487,010



19415

4/17/2008



Total Time			
Triangu	lar Pattern		
t (days)	Spacing (ft)		
142	3.00		
256	4.00		
386	5.00		
545	6.00		
744	7.00		





#### Job No.

79784

19415

# **HDR Computation**

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange: North of TR 234	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

1. Federal Highway Administration, "Prefabricated Vertical Drains - A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.

3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006) 4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

Assumptions:

- 1. Terzaghi's one-dimensional consolidation theory applies.
- 2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
- 3. Effect of disturbance related to soil displacement during installation is negligible.
- 4. Drain has infinite permeability (i.e. no drain resistance).

#### Input Values:

A =	1,285,961	sf	Total area North of TR 234 to be drained (Modified from DLZ, 2008)
C =	\$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
l	Triangular		Wick Drain Pattern
t =	225	day	available time to achieve desired degree of consolidation U _h
H =	29	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833		thickness of drain (Assume for 4" wide x 1/4" thick)
c _v =	0.081	ft²/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c _h =	0.0972	ft²/day	coefficient consolidation for horizontal drainage
	Note:		
	General Ca	ase: c _h =	1.2 to 1.5*c _v

-If layering of silt and sand in discontinuous lenses is evident:  $c_h = 2$  to  $4^*c_v$ 

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: ch = up to 10*cv

#### **Design Equations:**

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$
 (See FHWA eq. 1)

where,

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

 $U_v$  = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U _h = 0 %				
Uv = 90 %	t =	8805	days	Need to Consider Other Options.
$U = U_v = 90 \%$				
$T_v = 0.848$				
Calculate U _v that will occur in design period of t. t = 225 day $T = \frac{tc_v}{H^2}$				
$T_v = 0.02$				

FHWA eq. 1)

$$U_v = 0.17$$

Calculate required Uh

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_\nu)$$
(See  
U_h = 0.88

^{2.} Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.

	•	
HDR	Computation	

Job No.	79784	PID No.	19415
		• 10• • • • •	

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange: North of TR 234	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

$$t = \frac{D^2}{8c_h} F(n) \ln \left[ \frac{1}{1 - \overline{U}_h} \right]$$

(See FHWA eq. 8)

where,

 $\begin{array}{rll} t = & 225 \ \text{day} \\ \overline{U}_h = & 0.88 \\ c_h = & 0.0972 \ \text{ft}^2/\text{day} \\ F(n) = & 2.473098 \end{array}$ 

available time to achieve desired degree of consolidation  $U_h$  average degree of consolidation due to horizontal drainage coefficient of consolidation for horizontal drainage drain spacing factor

where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$
 (simplified) (See FHWA eq. 3)

 $d_w = \frac{2(a+b)}{\pi}$  $d_w = 0.23 \text{ ft}$  diameter of an equivalent circular drain (See FHWA eq. 9)

D = 5.663406 ft

required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.





Estimated total cost =	\$924,296.00	
Total linear feet wick drain =	1848592 lf	
Total number wick drains =	59632 ea	
Number Drain Spaces Along Outer Edge =	343.85 ea	
ength Outer Edge of Equilateral Triangle (or square) =	1723.31 π	

SCI-823 Portsmouth Bypass Project **JSA** Computed Date 4/17/2008 Shumway Hollow Road (TR 234) Interchange: South Area DMV Date 5/1/2008 Subject Checked 1 Of Wick Drain Analyses - Idealized Case Task Sheet 1

Job No.

Stage 1					
Triangular Pattern					
t (days)	Spacing (ft)	Cost (\$)			
30	2.15	1,426,295			
60	2.65	936,603			
90	3.13	671,057			
120	3.59	511,268			
150	4.03	407,325			
180	4.44	335,761			
210	4.83	284,425			
240	5.19	246,233			
270	5.53	217,109			
300	5.85	194,448			
330	6.15	176,235			
360	6.42	161,603			
390	6.68	149,606			
420	6.92	139,547			

Stage 1 90% Consolidation Time vs. Cost
$\begin{array}{c} 1,600,000\\ 1,400,000\\ 1,200,000\\ \hline \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\ \\$

	Stage 2				
Т	Triangular Pattern				
t (days)	Spacing (ft)	Cost (\$)			
30	2.34				
60	3.01				
90	3.64				
120	4.23				
150	4.77				
180	5.27				
210	5.72				
240	6.14				
270	6.51				
300	6.85				
330	7.15				

Total Time						
Triangu	Triangular Pattern					
t (days)	Spacing (ft)					
142	3.00					
256	4.00					
386	5.00					
545	6.00					
744	7.00					





#### 79784

19415

PID No.

79784 Job No.

PID No.

# **HDR** Computation

19415

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange: South of TR 234	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

- 1. Federal Highway Administration, "Prefabricated Vertical Drains A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
- 2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
- 3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006) 4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

#### Assumptions:

- 1. Terzaghi's one-dimensional consolidation theory applies.
- 2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
- 3. Effect of disturbance related to soil displacement during installation is negligible.
- 4. Drain has infinite permeability (i.e. no drain resistance).

#### Input Values:

A =	364,631	sf	Total area South of TR 234 to be drained (Modified from DLZ, 2008)
C =	\$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	315	day	available time to achieve desired degree of consolidation U _h
H =	29	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c _v =	0.081	ft²/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c _h =	0.0972	ft²/day	coefficient consolidation for horizontal drainage
	Note:		
	General C	ase: c _h =	1.2 to 1.5*c _v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: ch = up to 10*cv

#### **Design Equations:**

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$
 (See FHWA eq. 1)

where,

U = overall average degree of consolidation

- U_h = average degree of consolidation due to horizontal (or radial) drainage
- Uv = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U _h =	0 %				
Uv =	90 %	t =	8805	days	Need to Consider Other Options.
$U = U_v =$	90 %				
T _v =	0.848				
ulate U _v that wi	Il occur in design period of t.				
+ -	215 day				

Calcul

t = 315 day  

$$T = \frac{tc_v}{H^2}$$

$$T_v = 0.03$$

$$U_v = 0.20$$

Calculate required Uh

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$
 (See FHWA e  
U_h = 0.88

q. 1)

	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange: South of TR 234	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

Job No.

$$t = \frac{D^2}{8c_h} F(n) \ln \left[\frac{1}{1 - \overline{U}_h}\right]$$

(See FHWA eq. 8)

where,

 $\begin{array}{rll} t = & 315 \mbox{ day} \\ \overline{U}_{h} = & 0.88 \\ c_{h} = & 0.0972 \mbox{ ft}^{2}/\mbox{ day} \\ F(n) = & 2.6532 \end{array}$ 

available time to achieve desired degree of consolidation U_h average degree of consolidation due to horizontal drainage coefficient of consolidation for horizontal drainage drain spacing factor

where,

$$F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$$
 (simplified) (See FHWA eq. 3)

 $d_w = 2(a+b)/\pi$  $d_w = 0.23 \text{ ft}$  diameter of an equivalent circular drain (See FHWA eq. 9)

D = 6.781017 ft

required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.

79784

PID No.

19415



Optimum Drain Spacing based on required diameter of cyliner of



# COMPUTATIONS

**SCENARIO 3** 

**OPTION 2** 

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SCI-823 Portsmouth Bypass **JSA** Date 4/17/2008 Project Computed Subject Shumway Hollow Road (TR 234) Interchange: North of TR 234 Checked DMV Date 5/1/2008 Wick Drain Analyses - Idealized Case 1 Of Task Sheet 1

Stage 1							
Triangular Pattern							
t (days)	Spacing (ft)	Cost (\$)					
30	2.15	5,013,754					
60	2.65	3,289,813					
90	3.13	2,355,380					
120	3.59	1,793,257					
150	4.03	1,427,767					
180	4.44	1,176,171					
210	4.83	995,736					
240	5.19	861,583					
270	5.53	759,283					
300	5.85	679,691					
330	6.15	615,769					
360	6.42	564,417					
390	6.68	522,304					
420	6.92	487,010					



	Stage 2	
T	riangular Patte	rn
) t (days)	Spacing (ft)	Cost (\$)
30	2.34	
60	3.01	
90	3.64	
120	4.23	
150	4.77	
180	5.27	
210	5.72	
240	6.14	
270	6.51	
300	6.85	
330	7.15	

Total Time							
Triangu	Triangular Pattern						
t (days)	Spacing (ft)						
142	3.00						
256	4.00						
386	5.00						
545	6.00						
744	7.00						





# 19415

# HDR

PID No.

Job No.

79784

79784 Job No.

19415

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange: North of TR 234	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

**References:** 

- 1. Federal Highway Administration, "Prefabricated Vertical Drains A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
- 2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
- 3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
- 4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

#### Assumptions:

- 1. Terzaghi's one-dimensional consolidation theory applies.
- 2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
- 3. Effect of disturbance related to soil displacement during installation is negligible.
- 4. Drain has infinite permeability (i.e. no drain resistance).

#### Input Values:

A =	1,285,961	sf	Total area North of TR 234 to be drained (Modified from DLZ, 2008)	
C =	\$0.50	cost/lf	Material + Installation Cost	
	Single		Vertical Drainage (Single or Double)	
	Triangular		Wick Drain Pattern	
t =	225	day	available time to achieve desired degree of consolidation U _h	
H =	29	ft	height of compressible layer	
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)	
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)	
c _v =	0.081	ft²/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)	
c _h =	0.0972	ft²/day	coefficient consolidation for horizontal drainage	
	Note:			
	-General Ca	se' c. =	1.2 to 1.5*c.	

General Case:  $c_h = 1.2$  to  $1.5^*c_v$ 

-If layering of silt and sand in discontinuous lenses is evident:  $c_h = 2$  to  $4^*c_v$ 

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: c_h = up to 10*c_v

#### **Design Equations:**

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$
 (See FHWA eq. 1)

where,

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U _h =	0 %				
Uv =	90 %	t =	8805	days	Need to Consider Other Options.
$U = U_v =$	90 %				
T _v =	0.848				
Calculate $U_v$ that w	/ill occur in design perio	d of t.			
t =	225 day				
T =	$\frac{tc_v}{H^2}$				
T _v =	0.02				

 $U_v =$ 0.17

Calculate required U_h

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$
$$U_h = 0.88$$

(See FHWA eq. 1)

$\Big)$	Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
	Subject	Shumway Hollow Road (TR 234) Interchange: North of TR 234	Checked	DMV	Date	5/1/2008
	Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

Job No.

79784

PID No.

19415

$$=\frac{D^2}{8c_h}F(n)\ln\left[\frac{1}{1-\overline{U}_h}\right]$$

(See FHWA eq. 8)

where,

t

 $\begin{array}{rcl} t = & 225 \ \text{day} \\ \overline{U}_{h} = & 0.88 \\ c_{h} = & 0.0972 \ \text{ft}^{2}/\text{day} \\ F(n) \approx & 2.473098 \end{array}$ 

available time to achieve desired degree of consolidation  $U_h$ average degree of consolidation due to horizontal drainage coefficient of consolidation for horizontal drainage drain spacing factor

where,

 $F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$  (simplified) (See FHWA eq. 3)

 $d_w = 2(a+b)/\pi$  $d_w = 0.23 \text{ ft}$ 

diameter of an equivalent circular drain (See FHWA eq. 9)

D = 5.663406 ft

required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.





SCI-823 Portsmouth Bypass Project **JSA** 4/17/2008 Computed Date Shumway Hollow Road (TR 234) Interchange: South of TR 234 DMV 5/1/2008 Date Subject Checked Wick Drain Analyses - Idealized Case Task Sheet 1 Of 1

Job No.

Stage 1							
Triangular Pattern							
t (days)	Spacing (ft)	Cost (\$)					
30	2.15	1,426,295					
60	2.65	936,603					
90	3.13	671,057					
120	3.59	511,268					
150	4.03	407,325					
180	4.44	335,761					
210	4.83	284,425					
240	5.19	246,233					
270	5.53	217,109					
300	5.85	194,448					
330	6.15	176,235					
360	6.42	161,603					
390	6.68	149,606					
420	6.92	139,547					



79784



Tota	Total Time				
Triangu	Triangular Pattern				
t (days)	Spacing (ft)				
142	· 3.00				
256	4.00				
386	5.00				
545	6.00				
744	7.00				





19415

PID No.
#### Job No. 79784

19415

# **HDR Computation**

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Γ			X

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008	
Subject	Shumway Hollow Road (TR 234) Interchange: South of TR 234	Checked	DMV	Date	5/1/2008	
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2	

References:

- 1. Federal Highway Administration, "Prefabricated Vertical Drains A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
- 2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
- Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
   SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

#### Assumptions:

- 1. Terzaghi's one-dimensional consolidation theory applies.
- 2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
- 3. Effect of disturbance related to soil displacement during installation is negligible.
- 4. Drain has infinite permeability (i.e. no drain resistance).

#### Input Values:

A =	364,631	sf	Total area South of TR 234 to be drained (Modified from DLZ, 2008)
C =	\$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	315	day	available time to achieve desired degree of consolidation U _h
H =	29	ft	height of compressible layer
a =	0.33333	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c _v =	0.081	ft²/day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c _h =	0.0972	ft²/day	coefficient consolidation for horizontal drainage
	Note:		
	-General Ca	ase: c _h =	1.2 to 1.5*c _v

-If layering of silt and sand in discontinuous lenses is evident: ch = 2 to 4*cv

-For varved clays and other deposits containing embedded and more or less continuous permeable layers:  $c_h = up$  to  $10^* c_v$ 

#### **Design Equations:**

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$
 (See FHWA eq. 1)

where,

Calcul

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

 $U_v$  = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

U _h =	0 %					
Uv =	90 %		t =	8805	days	Need to Consider Other Options.
$U = U_v =$	90 %					of a definition of the second s
T _v =	0.848					
t = T -	1000000000000000000000000000000000000	period of t.				
T _v =	0.03					

(See FHWA eq. 1)

 $U_v = 0.20$ 

Calculate required U_h

 $\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$  $U_h = 0.88$ 

Job No.	79784	PID No.	19415

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange: South of TR 234	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

$$= \frac{D^2}{8c_h} F(n) \ln \left[\frac{1}{1 - \overline{U}_h}\right]$$

(See FHWA eq. 8)

where,

t

 $\begin{array}{rll} t = & 315 \mbox{ day} \\ \overline{U}_{h} = & 0.88 \\ c_{h} = & 0.0972 \mbox{ ft}^{2}/\mbox{ day} \\ F(n) = & 2.6532 \end{array}$ 

available time to achieve desired degree of consolidation U_h average degree of consolidation due to horizontal drainage coefficient of consolidation for horizontal drainage drain spacing factor

where,

 $F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$  (simplified) (See FHWA eq. 3)

 $d_w = 2(a+b)/\pi$ 

diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

D = 6.781017 ft

required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.





Job No. 79784

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19415

	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/17/2008
Subject	CR 28 Interchange: Mainline Embankment	Checked		Date	
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	1

Stage 1 - 50% Consolidation				
Triangular Pattern				
t (days)	Spacing (ft)	Cost (\$)		
30	3.28	861,383		
60	4.71	419,556		
90	5.87	271,453		
120	6.79	203,863		
150	7.49	167,531		
180	8.05	145,532		
210	8.51	130,471		
240	8.95	117,959		
270	9.46	105,765		
300	10.14	92,320		





Total Time			
Triangular Pattern			
t (days)	Spacing (ft)		
92	3.00		
151	4.00		
230	5.00		
332	6.00		
461	7.00		





Job No.

79784

19415

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			1

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange: Mainline Embankment	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

- 1. Federal Highway Administration, "Prefabricated Vertical Drains A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
- 2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
- Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
   SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

#### Assumptions:

- 1. Terzaghi's one-dimensional consolidation theory applies.
- 2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
- 3. Effect of disturbance related to soil displacement during installation is negligible.
- 4. Drain has infinite permeability (i.e. no drain resistance).

#### Input Values:

A =	349,313 sf	Total ramp area at CR 28 Interchange to be drained (DLZ, 2008)
C =	\$0.50 cost/lf	Material + Installation Cost
	Single	Vertical Drainage (Single or Double)
1	Triangular	Wick Drain Pattern
t =	128 day	available time to achieve desired degree of consolidation U _h
H =	43.5 ft	height of compressible layer
a =	0.33333 ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833 ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c _v =	0.081 ft ² /day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c _h =	0.0972 ft ² /day	coefficient consolidation for horizontal drainage
1	Note:	
	General Case: c _h =	1.2 to 1.5*c _v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers:  $c_h = up$  to  $10^* c_v$ 

#### **Design Equations:**

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$
 (See FHWA eq. 1)

where,

U = overall average degree of consolidation

U_h = average degree of consolidation due to horizontal (or radial) drainage

 $U_v$  = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

 $U_h =$ 0 % Uv =50 % Need to Consider Other Options. 4585 days t =  $U = U_v =$ 50 % 0.19625  $T_v =$ Calculate U_v that will occur in design period of t. t = 128 day  $T = \frac{tc_v}{H^2}$ 

$$T_v = 0.01$$
  
 $U_v = 0.08$ 

Calculate required U_h

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$
$$U_h = 0.45$$

(See FHWA eq. 1)

		Job No.	79784		PID No.	19415
HD	R Computation					
Project	SCI-823 Portsmouth Bypass		Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange: Mainline Embankment		Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case		Sheet	2	Of	2

$$=\frac{D^2}{8c_h}F(n)\ln\left[\frac{1}{1-\overline{U}_h}\right]$$

(See FHWA eq. 8)

where,

t

t = 128 day $\overline{U}_{h} = 0.45$  $c_{h} = 0.0972 \text{ ft}^{2}/\text{day}$ F(n) = 2.806234 available time to achieve desired degree of consolidation U_h average degree of consolidation due to horizontal drainage coefficient of consolidation for horizontal drainage drain spacing factor

where,

$$F(n) = \ln \left(\frac{D}{d_w}\right) - 0.75$$
 (simplified) (See FHWA eq. 3)

d_w = 2(a+b)/π

diameter of an equivalent circular drain (See FHWA eq. 9)

 $d_w = 0.23 \text{ ft}$ 

D ≔ 7.902355 ft

required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.



 Optimum Drain Spacing based on required diameter of cyliner of

 influence to achieve primary consolidation within given design period:

 6.99
 ft

 Length Outer Edge of Equilateral Triangle (or square) =
 898.17 ft

 Number Drain Spaces Along Outer Edge =
 128.43 ea

 Total number wick drains =
 8442 ea

 Total linear feet wick drain =
 384111 lf

intear feet wick drain -	304111
Estimated total cost =	\$192,055.50

Job No. 79784

PID No.

# HR

19415

)	oject	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/17/2008
Su	bject	CR 28 Interchange: Ramps	Checked	DMV	Date	5/1/2008
Та	sk	Wick Drain Analyses - Idealized Case	Sheet	1	Of	1

Stage 1 - 50% Consolidation												
Т	riangular Patte	rn										
t (days)	Spacing (ft)	Cost (\$)										
30	30 3.28											
60	4.71	254,641										
90	5.87	164,938										
120	6.79	123,965										
150	7.49	101,943										
180	8.05	88,611										
210	8.51	79,466										
240	8.95	71,890										
270	9.46 .	64,474										
300	10.14	56,306										





Tota	al Time
Triangu	ılar Pattern
t (days)	Spacing (ft)
92	3.00
151	4.00
230	5.00
332	6.00
461	7.00

**Consolidation Time vs. Minimum Drain Spacing** 12.00 10.00 Spacing (ft) 8.00 6.00 4.00 2.00 0.00 30 60 90 120 150 180 210 240 270 300 330 360 390 420 Time (days) -Stage 1 - Stage 2



Job No.

79784

PID No.

19415

# **HDR Computation**

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange: Ramps	Checked	DMV	Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	1	Of	2

References:

- 1. Federal Highway Administration, "Prefabricated Vertical Drains A Design and Construction Guidelines Manual." FHWA/RD-86/168, Washington, DC.
- 2. Department of the Navy, Naval Facilities Engineering Command, "Soil Mechanics." NAVFAC Design Manual 7.1, May 1982, pp. 241-259.
- 3. Subsurface Exploration Bridge and MSE Retaining Walls SR 823 Over Relocated Shumway Hollow Road SCI-823-0.00, Portsmouth Bypass (DLZ, 2006)
- 4. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)

#### Assumptions:

- 1. Terzaghi's one-dimensional consolidation theory applies.
- 2. Radial drainage theory (as it relates to vertical drains) is a function of time, drain diameter, spacing, coefficient of consolidation, and average degree of desired consolidation.
- 3. Effect of disturbance related to soil displacement during installation is negligible.
- 4. Drain has infinite permeability (i.e. no drain resistance).

#### **Input Values:**

A =	211,055 s	sf	Total ramp area at CR 28 Interchange to be drained (DLZ, 2008)
C =	\$0.50	cost/lf	Material + Installation Cost
	Single		Vertical Drainage (Single or Double)
	Triangular		Wick Drain Pattern
t =	94 0	day	available time to achieve desired degree of consolidation U _h
H =	43.5 1	ft	height of compressible layer
a =	0.33333 1	ft	width of drain (Assume 4" wide x 1/4" thick)
b =	0.020833 1	ft	thickness of drain (Assume for 4" wide x 1/4" thick)
c _v =	0.081	ft ^² /day	coefficient consolidation for vertical drainage (From Consolidation Tests on B-1 & B-2)
c _h =	0.0972	ft²/day	coefficient consolidation for horizontal drainage
	Note:		
	-General Ca	60' C =	1.2 to 1.5*c

-General Case: c_h = 1.2 to 1.5*c_v

-If layering of silt and sand in discontinuous lenses is evident: c_h = 2 to 4*c_v

-For varved clays and other deposits containing embedded and more or less continuous permeable layers: ch = up to 10*cv

4585

days

Need to Consider Other Options.

#### **Design Equations:**

With vertical drains the overall average degree of consolidation, U, is the result of the combined effects of horizontal (radial) and vertical drainage. The combined effect is given by:

t =

$$\overline{U} = 1 - (1 - \overline{U}_{h})(1 - \overline{U}_{v})$$
 (See FHWA eq. 1)

where.

U = overall average degree of consolidation

U_b = average degree of consolidation due to horizontal (or radial) drainage

U_v = average degree of consolidation due to vertical drainage

Check feasibility of 2 way vertical drainage only.

0 %  $U_h =$ Uv = 50 %  $U = U_v =$ 50 %  $T_v =$ 0.19625

Calculate U_v that will occur in design period of t.

$$t = 94 \text{ day}$$
$$T = \frac{tc_v}{H^2}$$
$$T_v = 0.00$$
$$H = 0.07$$

Calculate required Uh

$$\overline{U} = 1 - (1 - \overline{U}_h)(1 - \overline{U}_v)$$
$$U_h = 0.46$$

(See FHWA eq. 1)

Link No.	70784		10415
Job No.	79784	PID No.	19415

	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	CR 28 Interchange: Ramps	Checked		Date	5/1/2008
Task	Wick Drain Analyses - Idealized Case	Sheet	2	Of	2

$$=\frac{D^2}{8c_h}F(n)\ln\left[\frac{1}{1-\overline{U}_h}\right]$$

(See FHWA eq. 8)

where,

t

 $\begin{array}{rll} t = & 94 \ day \\ \overline{U}_{h} = & 0.46 \\ c_{h} = & 0.0972 \ ft^{2}/day \\ F(n) = & 2.654141 \end{array}$ 

available time to achieve desired degree of consolidation U_h average degree of consolidation due to horizontal drainage coefficient of consolidation for horizontal drainage drain spacing factor

where,

 $F(n) = \ln\left(\frac{D}{d_w}\right) - 0.75$  (simplified) (See FHWA eq. 3)

 $d_w = 2(a+b)/\pi$ 

diameter of an equivalent circular drain (See FHWA eq. 9)

d_w = 0.23 ft

D = 6.787405 ft

required diameter of the cylinder of influence of the drain (drain influence zone) to achieve consolidation within given design period.





\$157,680.25

Estimated total cost =

### CONCEPTUALIZED CONSTRUCTION SCHEDULE

$\bigcirc$																							FII	RST C	ONS			SEA	SON								
ITEM	1	2	3	4	5	6	7	8	٩	10	11	12	13	14	15	16	17	18	10	20	21	22	23	24	25	WEE 26		28	20	30	31	32	33	34	35	36	37
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REMOVE WASTE MATERIAL**** REMOVE WASTE MATERIAL****			1.35%																										<b>N</b> 197								Mete
MAINLINE EMB. Sta 415+00 to 520+00																																					
STAGE 1 CONSTRUCTION							_																														-
SHUMWAY HOLLOW INTERCHANGE					_																			_													
INSTALL WICK DRAINS						123																															1
NORTH MAINLINE EMB. Sta 384+00 to 415+00						1000							C Reference		149275				QU	ARAN		PERI	OD F	OR 5	FOOT	T WIC	K DR		PACI	NG (F	REAC	H 90%	6 CO	NSOL	IDAT	ION)	
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TR234 Ramp D																			QU.	ARAN	TINE	PER	IOD F	OR 5	FOO	T WIC	K DR	AIN S	PACI	NG (F	REAC	H 90%	6 CO	NSOL	IDAT	ION)	
TR234																			QU.	ARAN	TINE	PER	IOD F	OR 5	FOO	T WIC	KDR	AIN S	PACI	NG (F	REAC	H 90%	6 CO	NSOL	IDAT	ION)	
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TR234 Ramp B						_																	_	_			Parent and all									AIN S	
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LUCASVILLE-MINFORD									_																											1	
INSTALL WICK DRAINS								T					1			1							1							T	1				1	1	
MAINLINE EMB. Sta 520+00 to 537+00		-		-					100070							QUA	RAN	TINE	PERI	OD F	OR 7	FOO	TWIC	KDR	AIN S	PACI	NG (F	REAC	H 50%	6 COI	NSOL	IDATI	ON)		1	+	
Ramp A-D		1.000														Contraction and the	A STATE OF A			IOD F	and the second second second	and the second second			the second second second	and the second se		the second second second second		12 martine and the		A CAR HALF AND A MARKED					
0.0																																					
STAGE 2 CONSTRUCTION						_														_	_														1		
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SHUMWAY HOLLOW INTERCHANGE																																					
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MAINLINE EMB. Sta 384+00 to 415+00												-			-		-	-		-		-			-			-			-	-					-
TR234 Ramps A	-																								-												
TR234 Ramp D																																					-
TR234																																					
SOUTH																																					
MAINLINE EMB. Sta 352+00 to 384+00																																					
TR234 Ramp B			_		_				_		_											_		_			_									_	
TR234 Ramp C																																					
LUCASVILLE-MINFORD INTERCHANGE																																					
MAINLINE EMB. Sta 520+00 to 537+00																																					
CR28 Ramp A-D																																				·	
CR28																																					
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								38 CY				150/	014/51	1.5																							
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#### Wick Drain Cost Evaluation:

- Based on conversations with Mr. Steve Roy (Nilex Construction Group), Mr. Dave Panich (Terrasystems, Inc.), and Mr. Martin Taube (DGI-Menard), the average installed unit cost for wick drains ranges from \$0.30/LF to \$0.50/LF should no predrilling be required.
- Based on conversations with contractors, unit costs could increase by as much as \$2.00/LF if predrilling is required.
- Based upon review of two typical boring logs in the area of the Shumway-Hollow Interchange, Mr. Martin Taube (DGI-Menard) does not anticipate the need for predrilling.
- DLZ does not indicate a need for predrilling in their reports.
- Federal Highway Administration recommends or \$0.37/LF to \$0.61/LF for large projects (*see Publication No. FHWA-SA-98-086*).
- Based on information compiled from FHWA, conversations with contractors and engineering judgment an installed unit cost of \$0.50/LF is recommended for wick drains.

#### 2 ft. Sand Drainage Blanket Cost Evaluation:

Note: Reduced sand drainage blanket from 3 feet to 2 feet using lower end of DLZ's recommended 2 to 3 feet from their interchange reports. This is a modification from the 3-feet started in their plan sheets provided in their interchange report addendums.

- Based on the estimated wick drain treatment areas defined in SCI-823-6.81, Portsmouth Bypass Project, PID 19415 – Addendum to Report: Lucasville-Minford Road (CR 28) Interchange and SCI-823-6.81, Portsmouth Bypass Project, PID 19415 – Addendum to Report: Shumway Hollow Road (TR 234) Interchange, the total area to be drained equals 2,210,960 ft² (560,368 ft² + 1,650,592 ft²).
- For a 2 ft. drainage blanket, the total volume of sand equals 163,775 CY.
- Using a \$9.00/ton quote given by Hanson Aggregates (see attached), and assuming a unit weight of 125 PCF, the material unit cost for sand shipped to the site would be \$15.27/CY.
- Based on a conversation with Mr. Bill Launsberry (R.B. Jergens Contractors, Inc.), the material costs represent 90-95% of the installed cost for the sand blanket. Total unit cost ranges from 16.07/CY to \$16.97/CY.
- For comparison, the average unit cost for granular embankment from past projects in Kentucky (see attached "KYTC Average Bid Prices 2007") is approximately \$18.00/CY installed.
- Based on information compiled from KYTC, conversations with contractors and vendors, and engineering judgment, a unit cost of \$17.00/CY for the sand blanket is recommended.

H	R ONE COMPANY Many Solutions™	Telephone Record
Project:	SCI-823-6.81; PID 19415	Project No: 45878
Date:	4/25/2008	Subject: Wick Drain Installation Cost & Production Rate
Call to:	Mike Greenwald, Hanson Aggregates	Phone No: (937) 587-2671
Call from	: Justin Anderson, HDR	Phone No: (513) 984-7500

#### Discussion, Agreement and/or Action:

Mr. Greenwald stated that the estimated 165,000 CY of sand required for the drainage blanket (at the interchanges) would equate to approximately 280,000 tons and estimated a material cost of \$8.75-\$9.00 per ton after careful consideration (called me back after thinking over the numbers).

Note: \$9.00/TON equates to \$15.27/CY (based on 125 pcf used in Mr. Greenwald's calculation, which appears to be a very reasonable number.)

# **Telephone Record**

Project:	SCI-823-6.81; PID 19415	Project No: 45878
Date:	4/24/2008	Subject: Wick Drain Installation Cost & Production Rate
Call to:	Steve Roy, Nilex Construction Group	Phone No: 303-766-2000
Call from:	[;] Justin Anderson, HDR	Phone No: (513) 984-7500

#### Discussion, Agreement and/or Action:

HOR ONE COMPANY Many Solutions**

ONE COMPANY

Mr. Roy stated that wick drain installation costs generally range between \$0.50/LF and \$1.00/LF depending on project size. He also mentioned that the cost would likely be lower than the \$0.50/LF for a project with a large project like ours (i.e. Portsmouth Bypass Project).

With respect to productivity, a crew usually produces 15,000 ft/day and will work six 10-hour days per week. He said that they usually use 2 crews, but have regularly used 4 crews, and can use more than 4 crews if necessary.

Mobilization is \$1,500 per crew.

### HR ONE COMPANY Many Solutions**

# **Telephone Record**

Project:	SCI-823-6.81; PID 19415	Project No: 45878
Date:	4/24/2008	Subject: Wick Drain Installation Cost & Production Rate
Call to:	Dave Panich, Terrasystems, Inc.	Phone No: 540-882-4130
Call from	: Justin Anderson, HDR	Phone No: (513) 984-7500

#### Discussion, Agreement and/or Action:

Mr. Panich stated that the cost could vary between \$0.30 and \$0.40 for a job our size. However, if predrilling were required, it may add as much as \$2.00 per foot to the cost.

Estimated productivity rates are 10,000 to 20,000 feet/day/rig based on a 10-hour work day.

#### **ONE COMPANY** H **Telephone Record** Many Solutions™ Project: Project No: 45878 SCI-823-6.81; PID 19415 Date: Subject: 4/24/2008 Wick Drain Installation Cost & Production Rate Call to: Phone No: 412-257-2750 Martin Taube, DGI-Menard, Inc. Call from: Justin Anderson, HDR Phone No: (513) 984-7500

#### Discussion, Agreement and/or Action:

Mr. Taube stated that it does not appear that predrilling will be required based on the N values from the two sample logs (B-1307 and B-1326) provided. However, as the soils are stiff, adequate borings should be included in the bid set for the wick installer to make an adequate determination of whether or not predrilling is needed. Remember that if predrilling is required it will significantly increase the price of the wick drains. As the design advances, Mr. Taube is available for questions.

Mr. Taube recommends using \$20,000 mobilization and \$0.45/LF for the wick drain installation if no predrilling is required.

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-	II_ Bid Item #	ITEM DESCRIPTION	LINITS	OUANTITY	Average Price	<u>% total</u> dollars	Dollars	Occura
<u>Rank</u>	1 02200	ROADWAY EXCAVATION	CUYD	22,574,828	\$5.37	the state of the s	\$121,226,826	nces
	8 02230	EMBANKMENT IN PLACE	CUYD	5,306,618	\$5.37 \$6.08	2.09	\$32,264,237	85 50
	9 08100	CONCRETE-CLASS A	CUYD	66,294	\$467.08	2.09	\$30,964,602	
	17 08104	CONCRETE-CLASS A	CUYD	42,824	\$557.21	1.55		113
	36 21554EN	EXCAVATION	CUYD	1,635,601	\$5.94	0.63	\$23,861,961 \$9,715,470	55 7
	47 02223	GRANULAR EMBANKMENT	CUYD	388,314	\$17.94	0.83	\$6,966,353	36
	53 21553EN	EMBANKMENT	CUYD	965,548	\$5.59			30 7
	59 00021	DRAINAGE BLANKET-EMBANKMENT	CUYD	159,609	\$30.59	0.35	\$5,397,413	3
	68 08534	CONCRETE OVERLAY-LATEX	CUYD	2,663	\$1,405.44	0.32	\$4,882,439 \$3,742,687	34
	141 02555	CONCRETE OVERLAT-LATEX	CUYD	3337		0.24		
	148 22653EN	ROCK ROADBED	CUYD		\$414.88 \$24.68	0.09	\$1,384,455	19
	153 22830EN	ROCK ROADBED ROADWAY EXCAVATION SPECIAL UNDERCUT	CUYD	50,736	\$4.20		\$1,252,164	1
	158 08002		CUYD	289,111	N. Contraction of the second second	0.08	\$1,214,266	2
	160 02610	STRUCTURE EXCAV-SOLID ROCK	CUYD	38,631	\$30.02	0.08	\$1,159,703	55
	166 08001	RETAINING WALL-GABION		7,980	\$141.40	0.07		6
	173 02220	STRUCTURE EXCAVATION-COMMON	CUYD CUYD	56,694	\$19.23	0.07		39
	181 02403	FLOWABLE FILL REMOVE CONCRETE MASONRY		11346	91.26			23
	186 02235		CUYD	3,292	\$290.86	0.06		20
	223 20602EC		CUYD	123,853	\$7.07	0.06	1 1	6
	Sheet and the second		CUYD	3,563	\$192.94	0.04		3
	228 22831EN		CUYD	216,325	\$3.09	0.04		1
	233 20209EP69	GRANULAR PILE CORE	CUYD	21,076	\$29.69	0.04		9
	238 02690 240 02231		CUYD	3,255	\$180.15	0.04		38
		STRUCTURE GRANULAR BACKFILL	CUYD	14,738	\$39.15	0.04		34
	252 06490	CLASS A CONCRETE FOR SIGNS	CUYD	946	555.43		the state of the s	14
	374 08526	CONC CLASS M FULL DEPTH PATCH	CUYD	474	\$601.24	0.02		
	392 22655EN	UNDERCUT/STABILIZATION EXCAVATION	CUYD	174,969	\$1.50	0.02		
0	393 22529EN	PERVIOUS CONCRETE	CUYD	400		0.02		1
	496 02488	CHANNEL LINING CLASS IV	CUYD	19,989	\$7.94	0.01		
	515 22006EN	CONC CLASS AA-SUPERSTRUCTURE	CUYD	208		0.01		1
	525 02711	SEDIMENTATION BASIN	CUYD	1012		0.01		
	531 20911ED	HIGH SLUMP 3000 PSI GROUT	CUYD	805	164.29			
	559 20361ES601	CONCRETE PATCHING REPAIR	CUYD	14				
	638 03235		CUYD	2,884		0.01		
	679 05997	TOPSOIL FURNISHED AND PLACED	CUYD	1,790	and the second	0		
	791 02551	CONCRETE-CLASS A FOR STEPS	CUYD	40		0		
	842 02203	STRUCTURE EXCAV-UNCLASSIFIED	CUYD	1192		0		
	903 20210EP69	COHESIVE PILE CORE	CUYD	2394	and the second	0		
	907 20897ED	CONC FOR CRADLES-ANCHORS AND ENCASEMENT	CUYD	202		0	+ ,	
	933 02712	CLEAN SEDIMENTATION BASIN	CUYD	3,312		0		
	1229 02219	PIPE UNDERCUT	CUYD	391				
	1355 21952EN	CONCRETE FOR THRUST BLOCKS-ETC	CUYD	76				
	1421 22691EN	RIFFLE STRUCTURE-GABION	CUYD	71	\$100.00		and the second	
	1435 21953EN	UNCLASSIFIED EXCAVATION FOR UNDERCUTS	CUYD	300	and the second sec			1
	1567 02556	CONCRETE CAP	CUYD	3				
	1721 20315ED	CLAY SOIL CAP	CUYD	246				
	1766 20597EC	DITCH EXCAVATION	CUYD	535	\$4.00	0	\$2,140	1

Job No. 79784 PID No. 19415

# **HDR Computation**

Project	SCI-823 Portsmouth Bypass	Computed	JSA	Date	4/8/2008
Subject	Shumway Hollow Road (TR 234) Interchange: Mainline Embankment	Checked		Date	
Task	Determine Coefficient Consolidation for Vertical Drainage (Cv)	Sheet	1	Of	1

#### **References:**

1. SCI-823-6.81, Portsmouth Bypass Project, PID 19415, Addendum to Report: Shumway Hollow Road (TR 234) (DLZ, 2008)







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L	oad (psf)	Cv				٠			
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H _{comp} Ysoil Yfill H ₁ H ₂	 29 120 125 23 34	ft pcf pcf ft ft		Height Compressible Layer Unit Weight of Compressible Soil Unit Weight of Fill Stage 1 Fill Lift Height Stage 2 Fill Lift Height
σ _{v0} σ _{F1} σ _{F2}	 $\begin{split} & \gamma^{\star}(H_{comp}/2) = \\ & \sigma_{v0} + H_1^{\star}\gamma_{fill} = \\ & \sigma_{F1} + H_2^{\star}\gamma_{fill} = \end{split}$	4615	psf	Initial Stress at Midpoint of Compressible Layer Stress at Midpoint of Compressible Layer after placement of Stage 1 Fill. Stress at Midpoint of Compressible Layer after placement of Stage 2 Fill.

Based on Consolidation Testing on B-1 & B-2 and the estimated load due to additional Stage 1 & Stage 2 fill



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